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Zagreb, S., Zagrzeb, P., Agram.
Zavèršje, S., Piemonte in Istria.
Zatac, S., Saaz in Bohemia.
Zehrtene, Let., Ninigal in Livonia.
Zehse, Let., town of Wenden in Livonia.
Želézno-Město, S., Eisenstadt or Kis Marton in Hungary.
Z'emaiczei, Lit., Samogitia.
Zemun, S., Semlin.
Zgorzelica, P., Görlitz.
Zizzara semme, Let., Roman empire.
Zlutica, S., Ludisch in Bohemia.
Zmudź, P., Samogitia.
Zockov, S., Klingenberg in Bohemia.
Zumberak, S., Sichelburg in Croatia.
Žužemberk, S., Saisenberg in Carniola.
Zweibrücken, G., Deuxponts.

XXIII.—HINTS TO TRAVELLERS;

CONTAINING

1. *Report of Sub-Committee of the Royal Geographical Society, consisting of Capt. R. FitzRoy, R.N., and Henry Raper, Esq., R.N.; also 2. Papers by Rear-Admiral W. H. Smyth; 3. Rear-Admiral F. W. Beechey; 4. Lieut.-Col. W. H. Sykes; 5. Francis Galton, Esq., &c.*

PREFACE.

[APPLICATIONS are frequently made to the Council of the Royal Geographical Society by travellers about to set out for imperfectly known countries for instructions by which they may make their labours useful to geography. When a traveller addresses a specific question relating to a local matter, or some particular point of equipment as regards instruments of observation, it will generally be easy to refer him to some member of the Society whose experience may enable him to afford a satisfactory answer; but when he puts his question in a general form, it is extremely difficult for the Council to return a suitable reply.

It seems a natural solution of the difficulty that the Council should themselves draw up a body of instructions to meet such occasions. But some insuperable objections very speedily suggest themselves. A complete system of instructions adapted to general application would embrace every point which could present itself to the notice of the accomplished traveller, and such a work would be an encyclopædia. On the other hand, a few general remarks of an elementary nature would be superfluous to an individual of moderate attainments, while it could not possibly impart the necessary qualifications to one who had no other knowledge or experience of the subject. Again, the nature of the observations which a traveller may make must depend on the character and quality of the instruments he carries—that is, on the quantity of baggage which it may be convenient or safe to carry with him, and therefore on his personal resources. It is evidently as impossible to treat all such particulars to any useful purpose, as it would be to prescribe the equipment suited to the various unexplored regions of the world. But this is not all; differences prevail amongst experienced travellers themselves, not merely as to details of observations, the degree of accuracy which it is advisable to aim at, and other matters, but as to whether particular instruments should be carried or not.

On these grounds the Committee do not think it advisable to undertake the formal publication of instructions for travellers; nevertheless, as many valuable suggestions have been made by scientific men on the occasion of these applications, which they are desirous should be made accessible to travellers in quest of information on particular points, they have recommended the publication of certain papers which follow, with the names of the authors.]

Hints to Travellers.

With respect to such applications for instructions, it may be advisable to reply in the first instance with reference to special enterprises, and afterwards to compile more extended and detailed information for the use of travellers generally—if, indeed, so wide and comprehensive a range should be deemed within the province of the Royal Geographical Society.

Some inquiries refer more particularly to the case of "a traveller who proposes to visit really wild countries," and "to lay down a useful map of his journey."

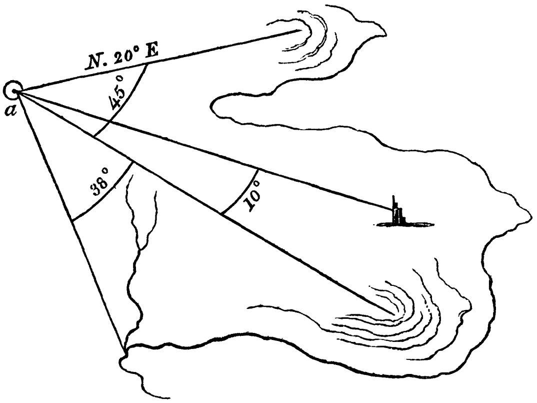
It is understood that he has already travelled, and has given proofs of his acquaintance with the use of several necessary instruments. Were not this the case, we fear that the fullest instructions would hardly suffice to give any traveller possession of such practical skill as should be acquired experimentally.

We think that the following list of instruments will be found sufficient for the traveller's purposes, and not too cumbersome or difficult to carry:—

A sextant, horizon, pocket-sextant, Kater's compass, Rochon's micrometer, and a sympiesometer, two pocket-chronometers, two thermometers, two portable barometers, two aneroids, and two boiling thermometers. It would be very desirable to carry a second sextant or circle, an additional horizon, and another prismatic compass, in case of accidents. Writing and drawing materials, stationery, scales, tapes, and register-books, should be carried in convenient cases—water-tight, if possible. With these, or even a part of these materials, a complete map may be laid down.

We consider the sextant (or circle) and horizon to be an efficient and reliable observatory for travellers, when accompanied by two or three chronometers. With such simple means there is far less risk of error than in using instruments of higher pretensions and more complicated structure.*

To lay down a useful map is an easier task than usually supposed, if correct principles be adopted and carefully followed in practice. A field-book (angle or bearing-book) should be always at hand, in which every particular relating to the direction travelled (or course), the distances, times, angles, bearings, and observations, should be noted on the spot and as they occur, as far as may be practicable: the less left to memory the better. Descriptions should be written with the objects *in view.* Times of occurrences, changes of course, and other data, should be noted as often as possible ; but that which is subsequently found invaluable when laying down the work permanently, is a collection of sketches of the country passed over, in *plan*, with a partial mixture of profile views, on which the angles observed or lines of bearing are traced by hand, with their corresponding figures written along them or across the angles, thus :—



By noting the angles and bearings on the *plan*, as well as in regular columns, in the field (or bearing, or angle) book, and inserting as many profile views, half-plan half-profile sketches, and horizontal plans, in the book as time will allow, an immense amount of perplexity will be prevented, and increase of accuracy will be ensured.

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* Raper's Navigation is a storehouse of information, not only on the practical use of instruments, but on the various methods of computing or reducing the observations by easy compendious calculations (suitable for the traveller on a journey, or the seaman in a gale); as well as by the longer and exactly accurate computations. Neither seaman nor traveller ought to leave England without the *latest* edition of this valuable work.—R. F.

Such plans as these are so many sketch maps made on the spot, from which accurate compilations may afterwards be made with comparative ease. In laying down or connecting points trigonometrically between the stations that are determined astronomically, true bearings and angles by reflecting instruments should be preferred to any use of the compass, which, however valuable as an auxiliary to fill in minor details, is not to be relied on in all places, and is apt to get out of order in consequence of its centre wearing by friction, as well as from other causes not always self-evident.

By fixing principal points astronomically, using trigonometrical connection between them, and filling in minor details by angles, bearings, and eye-sketches, it is surprising how much work may be done in a short time by a practised traveller.

For latitudes, besides the ordinary meridian or circum-meridional observations, single, double, or equal altitudes will be useful, the TIME being always obtained as accurately as may be.

Cross-altitudes* of stars are excellent, and easily obtained in tropical climates, where the sun is usually too high at noon for convenient observation in the artificial horizon.

Observations of the moon are not to be relied on to such accuracy as those of stars or the sun, on account of her parallax and irregularities. This applies still more to determinations of longitude by the right ascension or declination of the moon, in which a very small error of observation, or tabular position, will affect the result excessively.

For longitudes we think there is no method available for travellers in a wild country so sure and easy as cross-lunars.† A few good sets of cross-lunars taken in one night by the same observer, with the same instrument, will give the longitude within three miles of the truth. This is stated *confidently* as the result of experience. The altitudes must be calculated, for which the *time* must, of course, be known *nearly*. Differences of time by chronometers suffice for intermediate distances, and are, within such limits, most satisfactory. But in a country where there are good marks well defined, accurate meridian distances may be obtained by good differences of latitude and true bearings between points connected trigonometrically.

When equal altitudes are not obtained for time (with a view to ascertaining the error and rate of chronometers, or difference of longitude), absolute (single or independent) altitudes may be observed; and it should be remembered that those taken before noon should be compared with other forenoon sights, and those taken afternoon with other afternoon sights, in deducing the difference of time between places from their results.

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* By cross-altitudes we mean observations of stars on opposite sides of the zenith, and nearly equidistant from it.

† Observations of the moon's distance from stars, nearly equidistant, east and west.—R. F.

For base lines, the more rapid methods of attainment are alone suitable to the present object. No measure is more accurate and speedy than that obtained by meridian altitudes of the same heavenly body (sun or star, *not* the moon) at different stations, by the same observer, with the same instruments. If the stations are in the true meridian, or nearly so, their difference of latitude is their distance, near enough for our traveller's purpose; and if they are otherwise situated, their true bearing, obtained by an azimuthal observation of the sun or a star, and their difference of latitude, give the true meridian distance or difference of longitude between them, as well as their direct distance, the required base line.

If for particular purposes, such as a local plan, a short base line be required, an accurately measured board or pole, and a Rochon micrometer, or a sextant, will suffice. A short base may be measured first, two poles erected, and then a longer space ascertained by angular measurement. Field-work should be laid down on a moderately large scale, from a quarter of an inch to an inch, and for particular plans even several inches to a mile.

Magnetic observations, geological researches, mineralogy, zoology, botany, and ethnology, require the assistance of competent authorities on those subjects.

Your Sub-Committee will now add a few brief remarks on the instruments they have recommended.

Beautiful as instruments of a higher class than sextants and reflecting circles seem to be in theory, and are, when fixed securely and properly, in practice;—the great difficulty of finding a secure foundation for them to stand on, of adjusting them accurately (under the ordinary circumstances of a traveller), and of maintaining their exact adjustment while the observer is moving round them on, perhaps, unsound ground, are reasons which have induced us to think it unadvisable to recommend them to hurried travellers, who are not such adepts in their use as practised astronomers, and who might easily overlook an error of adjustment that would vitiate a whole set of observations.

Unless the results that are carefully recorded be those of observations made on correct principles, with instruments sufficiently accurate, practically as well as theoretically, all the time and pains they have cost are thrown away; and these consequences have been witnessed too frequently where transit, or azimuth and altitude, or other instruments *on stands* were employed.

It should be borne in mind that travellers cannot attempt to attain perfect accuracy in their observations made during a first exploration. It is not the fraction of a second of time, nor even the fraction of a mile of latitude that is required, but the degree and nearest minute.

All instruments should be in leather or canvas cases, painted *white*, slung by straps, and " becketed " * sufficiently.

Barometers and other glass instruments are better carried on men's backs (with the *upper* ends down) than in any other manner, but their bearers must of course be very careful.

If possible, chronometers should be worn *night and day*, to ensure uniform temperature and care. Motion affects chronometers far less than change of temperature.

The reflecting circle is an instrument highly esteemed (especially by the French), but it cannot measure an arc larger than 140° satisfactorily, on account of the extreme inclination of the index to the horizon glass. It is heavier and more cumbersome than a sextant of equal radius, and is more difficult to handle.†

A sextant with a doubly graduated arc and an additional horizon glass, will measure 160° satisfactorily.

When the sun is more than 80° high, his altitude cannot be taken in an artificial horizon, because the head of the observer obstructs the sun's rays while endeavouring to observe the altitude.

The roof of the artificial horizon should be portable, fitted to fold together, and, whenever used, should be reversed from time to time, so that half the altitudes should be taken with one end of the roof towards the observer, and the rest with the other. The trough should be smaller than usual, and raised in the roof by a thick bottom, so that an angle may be taken near the horizon. The mercury should be level with the edges of the trough, so that any dross may be scraped off by a piece of paper, or a *thin strip of wood*, kept in the box. Having the quicksilver level with the edges of the trough facilitates observing a low altitude. The mercury may be kept in a wooden, or in an iron bottle, with a screw-stopper and cap-funnel. To prevent spilling, the trough should have a notch at one corner *inside*, and be cut away *underneath*. The bottle should hold more mercury than will fill the trough, and a spare bottle should be carried. If all the mercury should be lost, coloured water will do nearly as well (dark or inky water). The horizon trough and roof should be placed on a flat plate of metal standing on three knobs. This will at once give a place for the horizon where the ground is uneven, wet, grassy, or soft. A leaden plate, about the size of a thin octavo book, with three knobs an inch long underneath, is suitable, because its weight steadies it among grass or in soft places.

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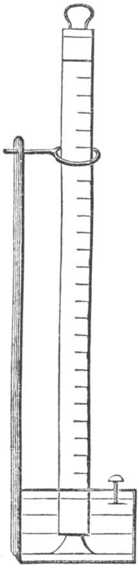
* Having loops or eyes of leather or cord at the sides or corners for slinging or fastening them, when travelling.

† The *repeating* reflecting circle is much praised by Col. Sabine. *See* also article upon it in the Penny Cyclopædia, under "*Sextant.*"—Ed.

The observer should endeavour to sit down on the ground, as near the artificial horizon as he can, in order to steady his arms and body, and avoid being disturbed by any wind. Cross-legged, with the elbows steadied on the knees, is a position as firm as can be maintained.

Rochon's micrometer is frequently useful as a telescope, carried in a case on the back.

Barometers might be made, for the special use of exploring travellers, in a simple manner. The tube should be unconnected permanently with the cistern, open at both ends, but capable of being hermetically closed temporarily at one end; it should be large, strong, and graduated on the glass. The cistern should be capable of admitting the tube when required, which should then be supported by a rod of iron screwed to the cistern, and steadying the tube by an arm with a clamp ring. There should be a float in the cistern, and, when not in use, the apertures for the float and tube should be closed by screws. The cistern should be of iron. The mercury should be clean, and as pure as possible, but not boiled.



Such a barometer might not give results *strictly* accurate, as independent measurements of pressure, but if filled carefully so as to exclude visible air-bubbles, duly compared with good standard instruments, and the temperature of the mercury, as well as that of the atmosphere, properly noted at each observation, it is believed that it would give valuable comparative results.

Several tubes might be carried in one strong case, *with the baggage*, and a spare one in a light metal case, to the place of observation.

HENRY RAPER, } *Sub-Committee.*
ROBERT FITZROY, }

Extracts from a Letter by Rear-Admiral Smyth, addressed to the Secretary.

THE first duty of a geographical traveller is the accurate determination of the route, stations, and topography of his journey; and the fewer instruments he is encumbered with the better will they be worked. Skilful mapping of regions little known is an actual boon to science, especially when accompanied by the observations of an intelligent mind. The general elevation of the countries passed over is ever a co-ordinate of importance, since much physical information may be derived therefrom as to the nature of production, modified by geographical position and consequent climate. Such are the appropriate ends of scientific travellers: but it should ever be borne in mind that quality, and not quantity, is the true end.

For he who explores Africa I may, from experience, advise that no accurate part of his instruments—as for instance the barometer-case—be made of wood; and everything should be exposed to a high heat before leaving London, perhaps equal to 120° in the shade, and 160° in the sun. No levels nor thermometers that will not stand this ordeal should be taken. The instruments should be few and simple, light and well-packed in non-conducting cases; and a portmanteau full of clothing is the very best packing-case for levels and thermometers, since the extremes of temperature will not be experienced therein. Thus, in a tent with the temperature of the day at 95°, a thermometer in a portmanteau was at 60° only.

An African traveller needs a pocket prismatic azimuth compass, with which he must take rounds of angles—including the sun—at all his stopping places, and on the road also if opportunity offers; but his best instruments should only be unpacked at crucial stations. He should have the most improved measuring tapes, and every opportunity must be taken of multiplying measurements of length for base-lines for filling in between standard positions by what may be deemed *dead-reckoning*. Still the most important object is an efficient angular instrument for fixing the latitude and longitude, without which the other work is comparatively useless. I alluded to this subject in my last Address to the Society, and have little to add unless a person were under drill. Latitudes, of course, will be measured by altitudes of the sun or stars in the meridian; but, for the determinations of longitude, more practice and attention will be required. Small differences may be measured by a chronometer, yet cannot be trusted, as the going-rate in African travelling is mostly useless: the capital measures made by Admiral Beechey, with two pocket chronometers, when a Lieutenant of the Adventure under my command, round the shores of the greater Syrtis, form a solitary exception. Absolute determinations by the moon, as I have said, must be looked to, not lunar distances—so often mischievous under unpractised hands—but altitudes of the moon and star, getting the right ascension when out of the meridian, or the declination when in the meridian. As to the favourite plan of observing the eclipses of the satellites of Jupiter, besides the uncertainty of instant, the method involves the necessity of carrying a telescope of power, and obtaining corresponding observations.

This is what is to be done; now how should we do it? A sextant is the most portable of instruments; but you must add thereto an artificial horizon, a heavy, lumbering thing, if good, and if of the best kind, namely, quicksilver, the fluid will assuredly be spilt and lost in the sand, besides some getting out and damaging the instrument. Then again, unpractised persons require a stand for the horizon, or the instrument, or for both; and at best you can only thus measure altitudes above and below a certain height, and so lose a great part of the sky, and that very part in which the sun is placed in Central Africa. A portable altitude-and-azimuth instrument, with its stand, would therefore be necessary to good work.

Now such a complication is adverse to the ends of the mere explorer, and therefore it is with equal pleasure and conviction that I recommend the Universal Instrument proposed by my son the Astronomer Royal of Scotland, who has had great experience of these matters in South Africa, during the late mensuration of an arc of the meridian in that country. It is a sextant when used for hand-work; or, if fastened on its stand, will measure any altitude and azimuth angles, give meridian transits on five wires, and the like, more conveniently and quickly than by the usual theodolites and other graduated instruments in use. It is, moreover, simple in construction, inexpensive, and easy to use; and a three-legged stand, for general purposes, is always readily carried, as it requires no care.

It remains to notice the determination of heights, independent of the troubles of levelling or trigonometry. The most accurate of the secondary methods in practice is, of course, by means of the barometer; but the difficulty of transporting this instrument (in my own opinion rather exaggerated) has been so greatly complained of by travellers, that mechanicians have turned their attention to the subject; and miniature barometers, sympiesometers, aneroids, and other substitutes have been the consequence. Yet such are the discrepancies of zero and scale, that, except the improved Adie's sympiesometer, the boiling thermometer is better than either of them, as keeping its zero constantly. But that method, though affording comparative ranges for a traveller in a new and wild region, is liable to very serious errors, particularly from the boiling taking place under unequal pressure when the steam is confined; nor is it easy to boil properly. The apparatus which I used was made expressly for me by M. Drescler at Palermo, in the year 1813, and consisted of a cylindrical pot, with a lamp appendage for boiling the water; and the thermometers were so mounted that half the scale could be turned up the back by a hinge, leaving only the bulb and part of the stem immersed in the hot water. This is the instrument mentioned in my account of Mount Etna (*Sicily and its Islands*, p. 145); and it is also described in Baron de Zach's *Correspondance Astronomique et Géographique.* Various experiments were made with it during my operations in the Mediterranean, merely, however, in comparison with the trigonometrical or barometric points.

But even in this boiling-point process, though on the whole so eligible, there is weight to carry, and trouble to take; and as, in addition to the importance of very frequent observations to get at the section of a country, readings of the barometer and thermometer will be absolutely necessary as an appendage to the astronomical work — it is my own opinion, that a small Adie's sympiesometer is the best instrument for an exploring traveller; and I may further say, that though a chronometer may undeniably be useful, still it is not importantly so, because absolute longitudes by the moon should always be aimed at: a mere seconds' watch will therefore do for intermediate work.

Extracts from a Letter by Rear-Admiral Beechey, addressed to the Secretary.

I believe that arcs by chronometer may be accurately measured, but with great care, and you may remember that some were done with excellent results, on my plan, by Dr. Colthurst, who went to the Colorado through Sonora. But a track by a pocket compass, well timed and filled into a form of this description, would tell a very good tale if checked by meridian altitudes and observations at the beginning and the end of the day:—

Date.	Place.	Time.	Bearing forward Track.	Bearing back Track.	Bearing of remarkable Objects.	Estimated Distance.

I do not think a transit instrument calculated for an exploring expedition. If the traveller has a caravan, and is going to remain a fortnight or more at a place, and then proceeds on again with the same means of transporting his baggage and instruments, a transit might be taken, as it could be fixed on a stand sufficiently stable for the purpose. But I should have no faith in moon culminations with a transit on a tripod: I would by far rather trust to lunars with a six-inch sextant. You may perhaps recollect that I have had a good deal of experience both with portable transits, and with lunars: a transit involves some kind of an observatory, and a meridian line; to have any results which are satisfactory with a transit, there must be convenience for observation, without letting in the wind or sand, and there must be stability in the instrument. Poor Ritchie took a transit, but I found it at Tripoli after his death, with many valuable scientific instruments, which he procured in this country and at Paris, and probably never used.

I should strongly recommend the sextant being fitted with a telescope with a horizontal wire in the focus of the field-glass, adjusted to a level on the top, after the manner of levelling instruments; for when so fitted and screwed to a stand, altitudes of hills and low altitudes of stars or other objects may be very accurately observed, and, with a cross level, altitudes of any elevation may be approximately determined; or a small collimator, such as I supplied Sir E. Belcher with, might be hooked on opposite the horizon-glass, which would answer the same purpose; or if loose, and placed on a wall or large stone, it would answer all the purpose of an artificial horizon.

Principal Instruments for the Track.

A six-inch sextant on a plan which will measure accurately *any angle.*

A double pocket sextant.

A good achromatic telescope fit for observing satellites of Jupiter and an occultation.

A prismatic azimuth compass and spare card and pin.

An artificial horizon.

Two pocket chronometers.

For meteorological purposes—Thermometers (small), barometer aneroid.

Pocket compass, for the track, to be hung round the neck and consulted at every turn of the road.

I do not think a Rochon of much use on such a journey; a sextant will measure with considerable accuracy small bases. I tried both in my survey of the Severn, and had the means of detecting every measurement; and I do not think Rochon so superior as to recommend it to a traveller about to explore a country. The longitudes of the principal places may always be determined with sufficient accuracy by lunars, E. and W., with a sextant. Jupiter's satellites, occultations and eclipses, should always be observed when practicable, as being valuable adjuncts.

The track between these places may be kept by D. R., by observing the course and the time of starting and of arrival at each place and at each turn in the road, and especially of final arrival at resting-place at night. The rate of travelling with camels or horses may be ascertained with considerable accuracy,* and any error in the track may be corrected by observations made before starting and after arrival at night.

The traveller should rigidly adhere to the rule of getting morning sights for chronometer before he starts from any place, and evening sights when he alights for the night; as the chronometer will thus be checked in its rate, which is not the same when travelling during the day as when resting during the night. He will therefore have to observe at every place, both evening and morning, for his chronometer, and as many more altitudes of stars as he thinks necessary for his latitude. This is tedious after a hot, fagging day's journey, but I always did it, and found the greatest satisfaction from it. He should, as before said, take his course and time throughout the day, and at noon alight and get the meridian altitude—connecting it with this track and with bearings of distant objects.

He should have a square book, ruled in inch or half-inch squares, to mark down the track and to delineate the topography as he proceeds. One set of lines should always be considered the magnetic meridian, and the track should be laid down upon it as the traveller proceeds, and as nearly in the right direction with respect to the meridian as possible for the eye to draw it. The squares should be considered as miles of distance, each square representing one mile, and all places be put down according to their estimated distances in their proper positions. A little practice will familiarize the traveller with this species of plotting, and the more careful he is in marking down objects the greater will be his satisfaction at the end of the day.

At night before he goes to rest he should look over his D. R. to run it out fair, and enter it at once in its proper column in his day's-work book. Bearings of remarkable points should be carried on from time to time as long as the objects can be seen, as they afford an excellent check to the track and a correcting point for the surrounding topography. These bearings should be particularly observed at the great turnings of the track-path, and astronomical bearing should be constantly resorted to. The azimuth may be computed from the time by chronometer, which will save the double observation.

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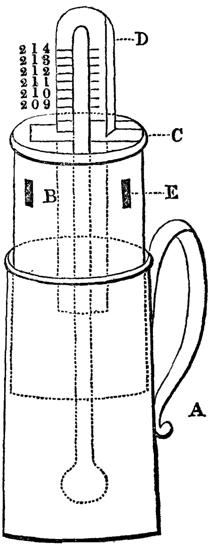
* I found the average rate of laden camels to be 2¾ miles per hour; they will walk considerably faster than this, but the difference is lost in the many little bends in the road which cannot be taken into account in plotting the track. The nature of the road will also vary their speed; a little experience will enable the traveller to estimate this correctly.—*See* my African journey from Tripoli to Egypt through Cyrene.

On the Use of common Thermometers to determine Heights.

[Extracted from the Paper by Lieut.-Col. W. H. Sykes, in Vol. VIII. of the Journal of the Royal Geographical Society.]

HAVING been recently applied to by two gentlemen about to travel—the one in Africa, and the other in Asia Minor—for a description of the thermometers and apparatus used by myself for some years in India for determining heights by the boiling temperature of water, I have ventured to believe that a brief account of a process which I found to produce results sufficiently near to the truth for most practical purposes may not be unacceptable to some members of the Society, particularly as I carried on my barometrical observations contemporaneously, and thereby obtained data for fixing the value of certain points on the thermometric scale. To determine heights accurately, good barometers are necessary, which have been carefully compared with a standard barometer; the observations must be taken simultaneously at the upper and lower stations, and the temperature of the mercury and the air, and the hygrometric state of the latter, must be noted. Heights so determined, when tested again in the same or succeeding years, I have rarely found to vary more than 10 or 20 feet in 4000 or 5000. When barometers are used which have not been previously compared with a standard, when the observations are not simultaneous, and when the pressure and temperature at the level of the sea are *assumed*, the results may by accident be near to the truth, but they will usually be from 100 to 300 feet wrong—at least such is the result of my experience within the tropics. But good barometers are very costly; they are troublesome to carry, are particularly exposed to accident on a journey, and get out of order by the escape of the mercury, which being frequently unobserved, the barometer continues to be used as if it were correct. The late Archdeacon Wollaston, aware of these facts, invented the thermometric barometer to supply the place of the ordinary barometer. This instrument is very sensible, but it is very fragile from the great weight of the bulb compared with the slenderness of the stem: moreover, there are some complex accompaniments, and the instrument is also expensive. In short, I found it not fit for *rough work* out-of-doors, having had three destroyed at the outset of my labours; and the same opinion is expressed by Mr. James Prinsep, of Calcutta, who is well known for the practical application of his scientific knowledge. I had then recourse to common thermometers, and, with certain precautions in their use, found them answer my purpose sufficiently well. A tin shaving-pot was my boiler; dry sticks and pure water were usually to be had, and by the time my barometers were settled I was ready to take the boiling temperature. The following is a sketch of the apparatus.

It will be seen that the chief part of the scale usually attached to the thermometer is removed, only so much of it being left as may be desirable: I, however, permitted the brass scale of one of my thermometers to remain, and I did not discover that it was the cause of error. Previously to taking the thermometers inland, it is necessary to ascertain their boiling points at the level of the sea; for in many instances the scales are so carelessly applied that a thermometer may indicate a boiling temperature of 213°, 214°, or 215°, at the level of the sea: one of mine stood at 214·2 when water boiled. Nevertheless, by making a deduction of 2° 2′ in all observations, the indications rarely differed five-hundredths of a degree from the other thermometer, of which the boiling point was 212°: the temperature of the air and the height of the barometer at the time the *verification* of the thermometers is made must be noted. The following is the manner in which my observations were taken:—from 4 to 5 inches of *pure* water were put into the tin pot; the thermometer was fitted into the aperture in the lid of the sliding-tube by means of a collar of cork; the tin tube was then pushed up or down to admit of the bulb of the thermometer being about *two inches* above the bottom of the pot. Violent ebullition was continued for ten minutes or a quarter of an hour, and the height of the mercury was repeatedly ascertained during that time, and the temperature of the air was noticed. Similar operations were repeated with a *second* thermometer; for it is never safe to rely upon *one* instrument. Having obtained the boiling points, it remains to determine the value of the indication of diminished pressure when the observations are taken above the level of the sea. The elastic tension of steam at different points on the thermometric scale has been determined by experiment, but not at regular intervals on the scale, nor with similar results, by different persons; tables,



A, A common tin pot, 9 inches high by 4 in diameter.
B, A sliding tube of tin moving up and down in the pot; the head of the tube is closed, but has a slit in it, C, to admit of the thermometer passing through a collar of cork which shuts up the slit where the thermometer is placed.
D, Thermometer, with so much of the scale left only as may be desirable.
E, Holes for the escape of steam.

therefore, computed from the formulæ of the various experimenters, do not accord; but, in three tables (by Mr. Prinsep, Lieut. Robinson, and one by an anonymous author in the Madras Gazetteer for 1824) which I have in my possession, the heights computed by them, when compared with heights determined by corresponding barometrical observations with previously compared barometers (the only satisfactory way to ascertain heights not taken trigonometrically), approximate sufficiently near for all practical purposes where great accuracy is not desired. These tables, however, differ slightly from each other.

TABLE I.—To find the Barometric Pressure and Elevation corresponding to any observed Temperature of Boiling Water between 214° and 180°.

Boiling Point of Water.	Barometer Modified from Tredgold's Formula.	Logarithmic Differences or Fathoms.	Total Altitude in Feet from 30·00 in. or the Level of the Sea.	Value of each Degree in Feet of Altitude.	Proportional Part for One-tenth of a Degree.
°			Feet.	Feet.	Feet.
214	31·19	00·84·3	- 1013	- 504	..
213	30·59	84·5	507	- 507	..
212	30·00	84·9	0	+509	..
211	29·42	85·2	+509	511	51
210	28·85	85·5	1021	513	..
209	28·29	85·8	1534	515	..
208	27·73	86·2	2049	517	..
207	27·18	86·6	2566	519	52
206	26·64	87·1	3085	522	..
205	26·11	87·5	3607	524	..
204	25·59	87·8	4131	526	..
203	25·08	88·1	4657	528	..
202	24·58	88·5	5185	531	53
201	24·08	88·9	5716	533	..
200	23·59	89·3	6250	536	..
199	23·11	89·7	6786	538	..
198	22·64	90·1	7324	541	54
197	22·17	90·5	7864	543	..
196	21·71	91·0	8407	546	..
195	21·26	91·4	8953	548	..
194	20·82	91·8	9502	551	55
193	20·39	92·2	10053	553	..
192	19·96	92·6	10606	556	..
191	19·54	93·0	11161	558	..
190	19·13	93·4	11719	560	56
189	18·72	93·8	12280	563	..
188	18·32	94·2	12843	565	..
187	17·93	94·8	13408	569	57
186	17·54	95·3	13977	572	..
185	17·16	95·9	14548	575	58
184	16·79	96·4	15124	578	..
183	16·42	96·9	15702	581	..
182	16·06	97·4	16284	584	..
181	15·70	97·9	16868	587	..
180	15·35		17455		59

TABLE II.—Table of Multipliers to correct the Approximate Height for the Temperature of the Air.

Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.	Temperature of the Air.	Multiplier.
°		°		°	
32	1·000	52	1·042	72	1·083
33	1·002	53	1·044	73	1·085
34	1·004	54	1·046	74	1·087
35	1·006	55	1·048	75	1·089
36	1·008	56	1·050	76	1·091
37	1·010	57	1·052	77	1·094
38	1·012	58	1·054	78	1·096
39	1·015	59	1·056	79	1·098
40	1·017	60	1·058	80	1·100
41	1·019	61	1·060	81	1·102
42	1·021	62	1·062	82	1·104
43	1·023	63	1·064	83	1·106
44	1·025	64	1·066	84	1·108
45	1·027	65	1·069	85	1·110
46	1·029	66	1·071	86	1·112
47	1·031	67	1·073	87	1·114
48	1·033	68	1·075	88	1·116
49	1·035	69	1·077	89	1·118
50	1·037	70	1·079	90	1·121
51	1·039	71	1·081	91	1·123

Enter with the mean temperature of the stratum of air traversed, and multiply the approximate height by the number opposite, for the true Altitude.

My thermometers were not graduated to less than half-degrees, and long practice enabled me to determine the height of the mercury in the stem to one-twentieth of a degree; but I would recommend thermometers being used in which the degrees are graduated to fifths or tenths of a degree. On the whole, I think the results of six years' experience justify me in saying that common thermometers may be satisfactorily used to supply the place of barometers in measuring heights where great accuracy is not required; and it will be recollected that what is usually looked upon as a difficult and troublesome operation with barometers, will be attainable by any person who carries with him a couple of thermometers, the requisite tin pot, and the tables, and who is master of the simplest rules of arithmetic.

Of the three above-mentioned tables I have chosen Mr. Prinsep's to submit to the Society, from their perspicuity and the facilities they offer for the conversion of boiling temperatures into heights with very little trouble; but a glance over the figures in my tables of altitudes, published in the eighth volume of the Journal of the Royal Geographical Society, will show that the tables are susceptible of considerable improvement; for, with two exceptions, all the heights deduced from Mr. Prinsep's and Lieut.

Robinson's are much below those determined by simultaneous observations with good barometers ; and I join with Mr. Prinsep in expressing a hope that every traveller boiling his thermometers will at the same time, if he possess a barometer, make a record of its indications, and thus render essential service to physics by fixing so many points on the scale of the elastic tension of steam at different temperatures.

When the thermometer has been boiled at the foot and at the summit of a mountain, nothing more is necessary than to deduct the number in the column of feet opposite the boiling point below from the same of the boiling point above: this gives an approximate height, to be multiplied by the number opposite the *mean* temperature of the air in Table II., for the correct altitude :—

	°	Feet.
Boiling point at summit of Hill Fort at Purúndhur, near Púna	204·2 =	4027
Boiling point at Hay Cottage, Púna	208·7 =	1690
Approximate height . . .		2337
Temperature of the air above . . .	75°	
Ditto ditto below . . .	83	
Mean	79=Multiplier. . .	1·098
Correct altitude		2·566 ft.

When the boiling point at the upper station alone is observed, and for the lower the level of the sea, or the register of a distinct barometer is taken, then the barometric reading had better be converted into feet, by the usual method of subtracting its logarithm from 1·47712 (log. of 30 inches) and multiplying by ·0006, as the differences in the column of "*barometer*" vary more rapidly than those in the "*feet*" column.

	Feet.	Feet.
Example.—Boiling point at upper station	185° =	14,548
Barometer at Calcutta (at 32°) 29 in. 75°		
Logar. diff. = 1·47712 — 1·43749 = 00363 × 0006 =		218
Approximate height		14,330
Temperature, upper station 76° Ditto lower 84°	} 80 = multiplier .	1·100
Correct altitude		15,763

Assuming 30·00 inches as the average height of the barometer at the level of the sea (which is, however, too much), the altitude of the upper station is at once obtained by inspection of Table I., correcting for temperature of the stratum of air traversed by Table II.

[*Note.*—Dr. Hooker finds that the index error of boiling point thermometers is often more than 1° even in instruments supplied by the best makers.—(1854).

According to Mr. Adie, optician, Edinburgh, the index error is liable to change from some hidden cause amounting to nearly a degree in a few months.

See Dr. Buist's paper on the Aneroid, page 43, vol. xxi. Royal Geographical Journal.]

Ed.

Letter addressed by Francis Galton, Esq., to the Secretary.

Sir,—When a man, for the first time in his life, proposes to explore a wild country, he is sure to ask, "What astronomical and mapping instruments ought I to take with me, and how should I pack and carry them?" It therefore seems to be a very proper undertaking for persons who have already had to do with these things, to record their experience in answer to the above question. And, further, I am sure it would be of infinite service to young travellers if different lists of instruments, books and stationery, were drawn up; each complete in itself, down to the minutest detail, so that a tyro having selected any one of them might straightway take it down to the different shops and order off-hand his complete outfit. He would then be satisfied that he had omitted to provide himself with no object of real importance, that he had bought nothing superfluous, and that the different items of his store corresponded together in size, in power, and in their several uses.

Half-a-dozen or more different lists might be drawn up; they would vary according to the accuracy of the results aimed at, to the character of the observations intended to be made, and also, to a great extent, according to the fancy of the person who might draw up the list.

But a young traveller would never go far wrong who followed to the letter any one of these lists. His danger lies in following the advice of observers who have little experience of the bush, or else in adopting scattered hints from many sources, and starting with instruments which, though individually good, are, when considered as a set, incongruous and incomplete.

A rough estimate of prices might be added to these lists, and hints on packing and carrying them would be of great importance. It is a desideratum as yet unsupplied, to arrange one or more light strong cases fit for strapping on an animal's back, or on men's shoulders, readily to be opened and unpacked, which shall contain all the books and instruments that a traveller requires for his daily use.

Guided by these views I will proceed to describe an outfit based upon that which I used, which would suit an explorer in any part of the world, who desired the means of bringing back as good geographical determinations, generally speaking, as explorers over large tracts of land have ever yet succeeded in obtaining. And in the list that I am now about to draw up professedly for an inexperienced observer, simple and well known instruments shall only find a place. I am very far indeed from thinking that instrument makers have yet learned to meet the wants of land travellers, but as we *know* that good results may be obtained from such sextants, &c., as are to be bought at any optician's shop, I would urge a young explorer to make *these* his mainstay; and if he takes other instruments, to do so more for the purpose of testing and reporting on their performances, than of relying in entire confidence upon their suiting him.

Again, it is hazardous for a man hurriedly preparing himself for a journey, to order new apparatus from a maker; he can never be sure that it will be made nicely or punctually, and he may have to set sail in possession of a strangely shaped instrument—very delicate, difficult to pack—whose adjustments he has not had opportunity of mastering, and on which nobody out of England can give information; whilst if he determines on buying a sextant, he may make his selection out of great numbers that are always ready made to hand, and practise himself in its use, under the tuition of the officers of his ship, during the whole of his voyage from England. It will, therefore, be my present object to give a list of instruments which, though confessedly improvable in numerous points, will, all things considered, be what I should advise a traveller of but little experience to provide himself with, and which, beyond all doubt, are thoroughly adequate to do his work.

Outfit for an Explorer.

A Sextant—

A sextant of five-inch radius, light in weight, by a first-rate maker, divided clearly, and on platinum, to quarter degrees. It must have a ground-glass screen fixed in front of the reading-off lens to tone down a glaring light, and a coloured glass to screw on to the telescope for index error purposes, in addition to the coloured shades.

The handle must be adapted for fixing on the telescope stand.

A Sextant—

A sextant of three-inch radius, graduated boldly to half degrees, in a leather case, like that of an azimuth compass, suitable for slipping on to a leather belt and being worn round the waist, if required.—Reserve, a second five-inch sextant, or other angular instrument of whatever kind the traveller may wish to take.

Artificial Horizon—

The trough must not be less than 3¼ inches, inside length; it must be of the usual construction for filtering the mercury when it is poured in. The glass screen must be a folding one, and by a first-rate maker.—

Reserve, one spare glass and a strong two-ounce glass bottle full of mercury, wrapped up loosely in a roll of clothes and well tied up and labelled.

Watch—

A common, strong, silver watch, not too heavy, with an open face and a second hand; it must wind up at the back. The hands should be black steel, not gilt, and they and all the divisions should be very clear and distinct. The performance of the watch is really a very secondary matter. 4*l.* is quite enough to give for it.—Reserve, at least two other watches of the same character; these should be rolled up separately, each in a loosely-wrapped parcel of dry clothes, say of old stockings, and they will never come to harm: they should be labelled, and rarely opened. Half a dozen spare watch glasses, fitting easily; two to each watch. Three spare watch-keys; one might be tied to the sextant-case, one wrapped up with each watch.

Compass—

An azimuth compass, graduated from 0° to 360°, and if the maker understands how to do it, have a shield of brass cut out here and there, to admit light, fixed over the glass.—Reserve, two spare glasses and a second azimuth compass.

Three common pocket compasses, from an inch to an inch and a half in diameter. Their needles must carry cards graduated, like those of the azimuth compass, from 0° to 360°, in addition to the points. These compasses should be very light in weight, have plenty of depth, and be furnished with catches. The needles should work steadily and quickly. Avoid one that makes long, slow oscillations.

Telescope—

One of 2¾-inch object-glass, for observing occultations of small stars and eclipses of Jupiter's satellites. The buyer should test it on the satellites, and be himself satisfied of its power, before concluding the bargain.

Stands—

A clamp to screw into a tree or a block of wood for the purpose of holding the telescope or sextant; one with three legs is perfectly useless to a traveller, for he has no table or anything else to put it on.

The ordinary telescope clamp makes a very good rest for a sextant by clamping a rod of wood, one end of which is weighted as a counterpoise, and the other, ending in a neck, is pushed through an auger-hole in the sextant handle, with a linch-pin stuck through its projecting end. Smooth action is not at all wanted for a sextant-rest.

Thermometers—

Two boiling-point thermometers. (Try them yourself against a good barometer to learn their index errors, at least; and recollect that for all purposes of determining heights, common water does just as well as distilled water.)

Two or three common thermometers, graduated to 160° at least, if for hot climates.

A pot arranged to boil the thermometer in.

Lantern—

I can only suggest a "bull's-eye," which was what I used: I wish I knew of a better. A small ball of spare wick. Oil.

Mapping Instruments—

Protractors—1 large circular brass one, 4 or 5 inches in diameter; 2 semicircular brass ones of 3½; all graduated, like your compasses, from 0° to 360°, and not twice over to 180°.

A station pointer for protracting sextant angles.

Two or three rulers of one foot each in ivory; a small square; a set of scales; small parallel rulers; compasses with pencil and pen; small pair of reserve compasses; fine ruling pen; a dozen artists' pins. Medium size measuring tape, say 12 yards; pocket ditto, 2 yards.

Additional Instruments not necessary, but convenient—

A pedometer of the best construction.

An Adie's sympiesometer.

I cannot recommend an explorer to have anything to do with either a chronometer or a mountain barometer.

Stationery—

A light board of the very best mahogany to rule and draw upon, as large as the writing-case will hold, say 11 inches by 7.

Plenty of metallic note-books, with spare pencils, all of one size, say 5 inches by 3½, or larger, with a leather pouch, having a flap buttoning easily over, to hold the one in use.

Two (or three) ledgers of strong ruled paper, 11 inches by 7, each with a leather binding; the pages should be numbered, and journal observations, agreements, sketches, and every single thing that is written, written in them.

Plenty of spare paper; it should be smooth, sufficiently thick, and fold up into 11 inches by 7.

A sheet of blotting-paper cut up and put here and there in the ledgers.

Tracing-paper, both black and transparent.

Blank map ruled for latitude and longitude.

Two dozen steel pens and holders; half a dozen fine drawing and holder; half a dozen FH pencils; half a dozen HB ditto.

Two penknives; India-rubber cut up in 5 or 6 bits.

Ink in abundance (ink-powders require vinegar). Red ink.

Paints, one cake or half a cake of each, viz. Indian ink, lake, cobalt, gamboge, oxgall, in a small tin case.

Half a dozen common paint brushes, one or two of which are kept in the case.

Books—

Raper's Navigation.

Nautical Almanack for current and future years, well bound.

Tables of Logarithms of Society of Useful Knowledge, well bound.

Tables for boiling-point thermometers.

Celestial Maps (uncoloured) pasted on canvas (and learn how to use them).

Three or four small 6*d.* or 1s. almanacks of any kind (the Nautical is far too cumbrous and on too bad paper for daily use; Hannay and Dietrichsen give a vast deal of information; the Seaman's Almanack, White's Ephemeris, &c.: they are useful to select and cut tables out of).

The best maps of the country you are going to visit that are to be obtained.

Notes on the above Outfit.

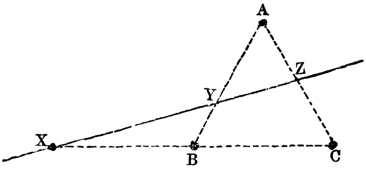
With these instruments, latitudes can easily be found to 300 yards; the sextant, mounted as it may be on a stand, will give nearly as accurate longitude as a sextant can be expected to give. When observing lunars with the larger one, the small sextant will take time at the end of each set as a check upon the watch. The telescope will give the traveller an opportunity of observing occultations of small stars, (not only those given in the Nautical Almanack, but also of others,) which is the most accurate way of finding longitude and the eclipses of Jupiter's satellites, which is the readiest way, and by no means so inaccurate a one as to be altogether worthless. For rapid reconnoitering expeditions on horseback the little sextant would be carried by a belt round the waist, and would give latitudes easily to 500 yards.

It may save trouble to others if I mention here the way which, after many trials, I adopted of observing with a sextant. During the day time I made out a list of the stars that culminated at convenient hours, and their expected altitudes. I set my watch by sunset, if it was very wrong, and spread my rug north and south in an open spot of ground, trampling down the bushes and long grass round it. Then, when the time of observing approached, I lighted my lantern and set it on the ground in front of my rug; to this I brought all my instruments, and first spreading a small cloth to the right of the lantern, I set my horizon on it, filled it with mercury, and covered it with a glass. The cloth was to catch any mercury that might be spilled. I then propped up my watch to the left of the lantern, laid down my note-book, with the leaves tied open, and taking out my sextant, adjusted it to the expected altitude, and screwing on the telescope, which always was kept at my focus, I laid myself flat down on the rug, and taking off the roof from the horizon if there happened to be no wind, and turning the glare of the lantern away from my eyes, and upon the watch, I made accurate contact of the star; then looking quickly round, I observed the watch. I now turned the lantern towards me, changed hands with the sextant, read off and wrote down, turned the lantern back on the watch and recommenced. For a meridian altitude I read off and wrote down about ten observations, both time and altitude, beginning a little before the star reached the meridian, and continuing after it had perceptibly sunk; it was thus easy to tell with accuracy what the meridian altitude really was. For lunars my sextant was always on a stand. I took time with another sextant before beginning, also two or three times during the progress of the lunar, and finally at the close of all. I was thus very independent of the good going of my watch, for by observing every half hour, no watch that went at all could be many seconds wrong. It is of very little consequence that the movements of a stand should be smooth and steady; its object is to so hold the sextant as to retain the moon and star in its field, while the observer is reading off and writing down. Neither of my instruments were fitted to a stand, but by very rough carpentering I made two which proved of infinite service and comfort to me, and which I have alluded to under the head telescope stand. The figures upon the face of a common watch are inconvenient in reading off minutes: therefore, in the first place open the glass, and with a pen and ink make a good conspicuous dot upon each five-minute division, and should you happen to make a blot, it does not in the least matter, for a wet finger entirely removes it. Next stitch together a watch-pocket, to be used when observing; it should be padded soft behind, and expose the face of the watch after the usual way, through a round hole cut out of the middle of a cardboard front. Now draw radiating lines on the outside of this cardboard opposite to each five-minute division, never mind if they are not very accurate, and write legibly on them in italics, the numbers 5, 10, 15, &c., up to 60. Many a mistake will be avoided by doing this, for after long observing the eye becomes sorely puzzled and all kinds of misreadings are put down. If the figures on the watch dial be faint, the numbers may be written over them, or the hour hand may be shortened and a paper ring pasted on to receive the new numbers; the observer can suit his fancy in this.

It will be most in place here for me to add what remarks I would make about sextant and other observations. If you commence to observe for longitude at all, make a regular night of it, working hard and steadily, and accumulating masses of observations at one station. Taking a few observations at many stations is time thrown away. Endeavour with much forethought to balance your observations. If you have to take a star's altitude for time east, select and wait for another star as nearly as may be of the same altitude west, and use the same telescope, horizon roof, &c. If a meridian altitude be taken north, choose another star and take it south, and so with lunars. In this way your observations will be in pairs, and the mean of each pair will be independent of all instrumental and refraction errors; and by comparing the means of these pairs, one with another, you will know your skill as an observer, and estimate with great certainty the accuracy that your results have reached. Never rest satisfied with your observations, unless you feel sure that you have gained means of ascertaining the limit beyond which you certainly are not wrong. Weight all your observations; that is, when you write them down, put good, very good, doubtful, &c., by their sides. When taking occultations, if the star be not down in the Nautical

Almanack list, do all you can to identify it by drawing diagrams of adjacent stars, and indicating the point of the moon's limb that occults it. Before observing, see that the minute hand and second hand of your watch go together, that is to say, that the minute hand is truly over a division when the second hand points 0 seconds; if it be not, move it till it is.

The azimuth compass is one of a traveller's most useful instruments. To use it, it is best to make a pile of stones and lay the cover of the compass on the top, with its bottom upwards; this makes a smooth table for the azimuth compass itself to be moved about on. Be on guard against magnetic rocks; it may happen that the bare peaks of high hills, which are the best of places for observing from, and which a traveller often makes great sacrifices to reach, are found so magnetic as to make compass observations worthless. The little sextant should always be taken up on these excursions. It is of little use in a wild country to devote much time to getting accurate bearings, as the landmarks themselves are rarely well defined: the main endeavour should be not to mistake one hill for another, to judiciously select good angles, and to carry on more than one independent scheme of triangulations at the same time, by comparison of which the accuracy of the whole may be tested. It is surprising how much work may be thrown away by want of judgment; and also how much may be done, with very little trouble, by a person who has acquired a good eye and memory of country. The daily difficulty of an explorer is to triangulate without leaving his caravan: to do this he must note the bearings of hills when they are in conjunction, and also when he happens to be in a straight line between them.



Thus, in travelling along X Y Z, the hills A B C can be mapped; for at X, or thereabouts, the bearing of B from C can be determined; at Y that of A from B; and at Z that of A from C; and so on for any number of hills. And it is very important to recollect that it is not necessary to catch these lines of sight precisely; for by taking bearings twice, and the intermediate course approximately, there are sufficient data for protracting out upon paper the required bearing. Thus, as soon as the peak of a distant hill is about to be occulted by the shoulder of a nearer one, a bearing should be taken; and again another one as soon as it has reappeared on the other side, and the intermediate course noted.

Suggestions for carrying the above Instruments.

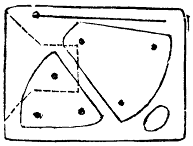
Wear a leather belt 1¾ inches broad round the loins, to the outside of which, besides any other pouches that you may wish to carry, the leather case of the azimuth compass and the leather pouch of the note-book are sewn. The place for the compass is against the small of the back; for the note-book, behind the right hip. The other instruments must be carried in cases. I have tried many ways myself, and if I were to start again on a journey I should adopt the following. First, I should divide the instruments into three groups, A. B. and C., of which I give the average weights:—

A.	Weight in lbs.
Five-inch sextant	2
Three-inch sextant	1¼
Horizon trough, bottle, and roof	2½
Thermometers and watch	¾
Loose sheets of tables, a ruler, protractor, compass, and pencil, spare watch glass	½
	7

B.	Weight in lbs.
Telescope (about)	4
Lantern	1½
Light stand and counterpoise	2
Spare oil	¾
Pot for boiling thermometers	½
	8¾

C.

Almanacks, maps, tables, mapping instruments, &c.



I should next fit up a common deal box, as a model, for group A., and would follow the general arrangement of the sketch, differing from it only so far as peculiarities, in the particular instruments bought, might render necessary. The horizon apparatus would slip into a separate compartment which did not communicate with the interior of the box, for fear of any mercury getting loose upon the instruments; its position is dotted out. The dark lines show the sizes of sextant boxes as usually made, so that plenty of room is allowed in the sketch for horse-hair stuffing. The small sextant I should pack in its leather case; for the larger one I should take no case at all. The thermometers, thrust into a thin tin case, would go along the upper part of the box, and a watch in the right hand lower corner: the size of the whole inside measurement is 11 inches by 7½, and about 4 deep. Having satisfied myself that the fittings of the box were secure and convenient, I would have a light one made of painted tin after its model; it should lock, and also have hooks to secure the lid, even when it was not locked. Places should be made for leather handles, one to go at each end of the box, and two, crossways, on the top. Its weight would be in all 4 lbs.—the box a little less than 3 lbs. and the stuffing rather more than 1 lb. This accomplished, I would order two more boxes of the same length and breadth, one of them of 4 inches deep to hold group B, which might be arranged with the telescope along one side, the lantern and thermometer pot end to end along the other, and the stand and counterpoise between them, while a flat oil-can an inch deep extending the whole breadth and depth of the box, or 7 inches by 4, would fit in a narrow compartment at one end. The third box should be a kind of writing-desk, and of a depth sufficient to hold group C, say 6 inches. The fitting up of this would be entirely a matter of fancy. Lastly, I would have a couple of thickly-quilted canvass bags, in which the boxes A and B might be slipped endways. Each bag should have a flap to button down, be painted some light colour, and have strong loops sewn at the four corners of its back. The weight of each bag would be 1½ lbs. Thus, A, box, bag, and all, would weigh 12½ lbs.; B, 14 lbs. These weights are certainly heavy, but they are practicable, and each package is very convenient for carrying as a knapsack or in any other way. For ship, boat, or waggon travelling, a light wooden chest should be procured which would just hold the three boxes, and then putting the quilted bags at the bottom, the boxes would lie one above another as the trays in a canteen. As a protection against the fearful jolting of a waggon, it would be advisable to inclose the chest in a large pannier and loosely to stuff up the interval between them with sacking, clothes, or anything else at hand. The outside measurement of the chest would be 13 inches long, 9 broad, and 15 inches deep; those of the pannier 5 inches larger every way.

Hints for Collecting Geographical Information.

1. *Aspect.*

1. What is the general aspect of the country?
2. Mountainous or hilly?—Sharp peaks or rounded outlines?
3. Of the coast? Abrupt or shelving? Rocky or in cliffs?
4. Downs of Sand? Low or flat?
5. Any active volcanoes? or traces of extinct ones? or their probable forms in the outline of the mountains?

2. *Surface.*

1. Is the surface level or undulating?
2. Has it a tendency to table lands, or steppes?
3. Is the soil rich or poor? loamy—sandy—boggy?
4. Are the plains fertile or barren? wooded or cultivated?
5. What its general capabilities?

3. *Physical Divisions.*

1. Note the chief divisions of the country.
2. Mark especially the line of separation of waters.
3. Trace the outlines of the principal basins of the chief rivers.
4. Group the country into basins as far as practicable; it will be found the simplest mode of describing it.
5. Trace also the limits of the secondary valleys comprising the tributaries to the main stream.
6. May they from position be called upper and lower basins?
7. Do distinct traces of mountainous—hilly—flat—wooded jungle—cultivated—sandy—marshy, or barren, country exist? if so, note their limits generally.

4. *Mountains.*

1. What the direction of the chief range, or ranges?
2. What the general form of outline? (Describe while in sight, *not* from memory.)
3. What is the *estimated* height (if no measurement can be had) of the chief points; and also of the general range?
4. Are any of them snow-capped? (State the season.)
5. How far down does the snow extend? (Note north or south side.)
6. Are they wooded?—At what height does the wood finish?

7. At what height does vegetation cease?
8. Are the mountains in groups or masses? or detached?
9. Obtain bearings, by compass, of the limits of the range, and of all remarkable points, masses, gaps, &c.
10. Mark the chief mountain-passes, and note if they might be easily defended against an enemy.
11. What their general structure?

5. *Rivers.*

1. What are the native names of the chief rivers?
2. Trace the general course of each; with its windings, if possible.
3. Does it receive many tributaries? note their names in order, from its sources, distinguishing on which side they join.
4. Is it navigable for large or small craft? and to what extent?
5. How far up does the tide reach? Is the current rapid? What its rate?
6. Does it flow by several outlets, or by one grand mouth to the sea?
7. Does it form a bar, or banks, or islands at its mouth?
8. What the width of the river at its outlet? and at various points?
9. Is the river ever fordable? Name the chief fords.
10. Does it form cascades, or rapids, or occasionally inundations?
11. Does it at any season lose itself in sand, or otherwise not reach the sea?
12. Does it flow from a lake, or from other sources or springs?
13. What may be the probable elevation of its source above the sea? measured or estimated?
14. Is the bed of the river gravel, sand, or mud? Does it bring down much detritus?
15. What the colour of the water? Does it retain it at any distance from land?
16. Is the river obstructed by islands, shoals, rocks, snags, or any obstacle to steam navigation?
17. Are its banks wooded? Is fuel easily procured?
18. Does it abound in fish? and in what species?
19. Is it navigated by native boats? and how far up?
20. Describe each affluent as a main stream, with its tributaries, marking the position of junction, and the angle at which it joins its recipient.

6. *Lakes.*

1. What the native names of the lakes?
2. What is the situation and extent of each?
3. What its level, above and below the sea? How ascertained?
4. Is it formed by rivers or springs? or does it feed any river?
5. Is it of salt or fresh water? Is it said to rise periodically?
6. What its general depth of water?
7. Are there any vessels or boats upon it? and of what size?
8. Are its banks rocky or steep, or low? Are they wooded or barren?
9. Could fuel be readily procured? Does it offer facilities, or the contrary, to steam navigation?
10. Are its shores thickly inhabited? Are birds, fish, shell-fish, &c., plentiful, and of what sort?
11. Are any marshes or ponds known, and where? Are they constant or periodical?

7. *Sea Coasts and Ports.*

1. Does the coast form gulfs, bays?
2. Promontories, peninsulas, capes, low points, &c.?
3. Is it abrupt, bold, rocky? or low, flat, and shoal?
4. Are there currents along the coast? Note their force and direction.

5. Name the chief *ports.* Are they secure harbours, or only open bays, or roadsteads for anchoring?
6. What the depth of water, and what bottom for anchoring?
7. Is the port capable of containing many vessels? Does it offer facilities for repairs?
8. Can water, provisions, and fuel be easily procured?
9. Note the time of high-water at full and change of moon, and rise and fall of tide; and direction and velocity of stream.

8. *Volcanoes and Mineral Springs, &c.*

1. Are any now active? or, are there traces of extinct volcanoes?
2. Give their position—height above the sea—and native names.
3. Does tradition or history record any eruption? at what date?
4. Was the eruption of fire, lava, scoriæ, water, or mud?
5. Are earthquakes frequent? Are there records of any having occurred?
6. What were their effects? how far did they extend? any up-heaving or depression of land recorded?
7. Are many *mineral springs* known? Hot, tepid, or cold? (Note the temperature if possible.) Are their waters used medicinally?
8. Do they form deposits? Siliceous or calcareous?

9. *Maps, Charts, &c.*

1. Do any charts of the coast, or maps of the country, or partial surveys exist? Native or otherwise? What their respective dates?
2. Are they believed to be accurate? Upon what scale?
3. Endeavour to map the country, starting, if possible, from a fixed point; if exact observations cannot be obtained, give compass bearings, and estimated heights and distances. (N.B. Heights may often be obtained by length of shadow, &c.; distance by velocity of sound, &c.) The scale of one inch to a geographical mile is recommended.
4. Take bearings of all remarkable objects in sight from any known station, as mountain-peaks, masses, gaps, towns, villages, forests, &c. &c., and transfer all to paper immediately; trust nothing to memory.
5. Preserve all original observations and documents relating to surveys; and make two or three copies of observations.
6. Obtain correct *native* names if possible, and keep to one standard of orthography. Mark all hearsay information with the initials of the informant. If a journey is made by night, or in foggy weather, trace it with coloured ink.

10. *Astronomical Observations.*

1. Are any positions astronomically determined? What reliance may be placed on them?
2. It is very important to obtain observations for the position of all capes, headlands, points, towns, villages, &c.; mountain-peaks, passes, limits of range, &c.; lakes, sources, confluence, and outlets of rivers; in short, of every remarkable object.
3. Endeavour to obtain the *latitude* by meridian altitude of the sun, or of a planet, or of a star, or of the moon.
4. *Longitude*—by eclipses of Jupiter's satellites, especially by eclipses of the third and fourth satellite, when both immersion and emersion can be observed,—or by any other eclipse; by moon culminating stars; by occultations of fixed stars by the moon; by lunar distances from the sun, or a planet, or a star, always East and West when possible; by an altitude of the moon in the prime vertical; or by chronometers:

state always by which method obtained, and what reliance may be placed on it.

5. Observations on the variation of the compass, and dip of the needle, are very important.

Instruments.

A repeating circle, or sextant of five-inch radius; a pocket sextant; an artificial horizon; Kater's compass; two mountain barometers; and two thermometers, with a good pocket chronometer; are sufficient for all common purposes.

Meteorology.

1. Keep an exact register of the barometer and thermometer.
2. What are the prevalent winds? What the periodical?
3. What the average fall of rain?
4. What the amount of evaporation, &c.

Natural History.

1. Note the geographical distribution of man, animals, birds, fishes, insects, plants, &c.
2. Obtain information on all branches of Natural History, bearing in mind that the useful and practical is of more importance than the merely curious.

For detailed instructions, under each head, recourse should be had to the respective sources.

Ethnography.

1. Obtain vocabularies of the native language—phrases rather than single words. Keep to a fixed standard of orthography in writing them down: the sounds of the vowels in *father—there—ravine—mole—lunar*, are recommended as the most simple, and as being both English and European.
2. Note the habits, manners, customs, and amusement of the natives.
3. What notion have they of a supreme being? what of a future life? what, if any, their religious ceremonies?
4. What their treatment of the aged, of the sick, and of children?
5. What seems to be the form of government? Is division of property recognised? Do they buy and sell land?
6. Do they trade or barter with each other, or with strangers?
7. Note the number of natives seen from day to day, distinguishing the sex, and children.
8. Are there many lunatics or idiots?
9. What the usual form of feature? the shape of the skull? hair? colour? stature? bodily constitution?
10. Is plurality of wives common? are women without husbands frequent?
11. Have they any marriage ceremonies? how do they treat their wives?
12. Do they give proof of capacity for civilization?
13. May the natives be trusted as guides—as messengers—or to procure food?
14. What presents please them best?
15. What words or signs do they use when hostile? or when friendly?
16. What are their dwellings? What their chief articles of food?
17. What their disposition—savage or gentle; rash, hasty, or inoffensive? Are they disposed to receive instruction?
18. Are any cases of cannibalism reported? N.B. To investigate strictly under what circumstances they occurred.
19. Are the people said to be increasing or decreasing?
20. Does slavery exist? What is the condition of a slave?

21. What are their diseases? What their medical treatment?
22. Can the traveller point out the most probable mode of civilizing and benefiting the natives?
23. What traditions are current respecting the origin of the people?
24. Collect all information that can throw light on the migration of nations.

N.B. The greatest forbearance and discretion are strongly recommended in all intercourse with the natives—never to allow an imaginary insult to provoke retaliation which may lead to bloodshed. It must be borne in mind their's is the right of soil—we are the aggressors.

DESCRIPTIVE GEOGRAPHY.

Names of Country.

Boundaries.

Configuration of Surface—

General Character; Mountains; Plains; Valleys.

Names, Passes, Culminating Points, Snow-level, Altitudes, Peculiar Phenomena, Outline of Base and on given Contours, Sections, Latitudes and Longitudes, Bearings and Distances.

Hydrography—

Rivers and Tributaries.

Course and Windings, Length, Section of Fall, Navigable Extent, Tidal Extent, Soundings, Velocity of Current, Banks, Fords, Inundations.

Lakes.

Outline, Sections of Depth, Feeders, Outfall, &c.

Marshes; Seas; Coasts; Harbours; Drainage Areas.

Topography and Itineraries.

Meteorology—

Winds; Rainfall; Temperature; Atmospheric Pressure; Evaporation; Meteoric and Magnetic Phenomena; Methods of Observation and Registration.

Zoology—

Species found in Country; Distribution of Animals; Useful Animal Products, Wild and Domesticated; Directions for Collecting, &c.

Botany—

Species found in Country; Distribution of Plants, &c.; Useful Vegetable Products, Wild and Cultivated; Directions for Collecting, &c.

Geology—

Geological Formations; Mineral Products; Soils; Directions for Collecting, &c.

Physical Divisions—

High and Low Lands; Drainage Areas; Forests; Heaths; Barren and Cultivated Ground; Pastures; and other divisions based on Geographical Distribution.

Cartography—

Examination of Existing Maps, Contributions to Cartography, Construction of New Maps, the Methods of Geodesical and Astronomical Observation.

ETHNOLOGY AND STATISTICS.

Population—

Names of Nation, Tribe, &c.; Geographical Distribution; Total Number; Number of families, &c., Males, Females, Children; Characteristic Form,—dimensions, weight, colour, odour free from uncleanliness, hair, features; Unnatural modifications of form,—by pressure, mutilation, incision, &c.; Moral and Intellectual Character; Diseases,—corporeal and mental; the Generation, Development, and Vitality of the Population; Classifications of Population; Condition of various classes.

Habitations—

Distribution, Character, Number.

Communications—

By Land and by Water.

Occupations—

Pastoral, Agricultural, Maritime, Arts, Manufactures, Trades, Commerce, &c.; Ceremonies, Amusements, &c.

Food; Costume; Utensils; Weapons and Warfare; Weights, Measures, Division of Time.

Language—

Literature, Books, MSS., Inscriptions, Picture Writings, Songs, Tales, &c.; Vocabularies of natural objects, qualities, action, relationship, numerals, pronouns, positionals, &c.; Grammatical Variation of Words; Construction of Sentences; Dialectic Variations; Intonation and peculiar Utterances; Geographical Distribution of the Language.

Music—

Vocal and Instrumental.

Religion; Traditions.

History—

Origin, Migrations, Increase and Decrease of Territory.

Government—

Territorial Divisions, Laws, Functionaries.

Foreign Relations.